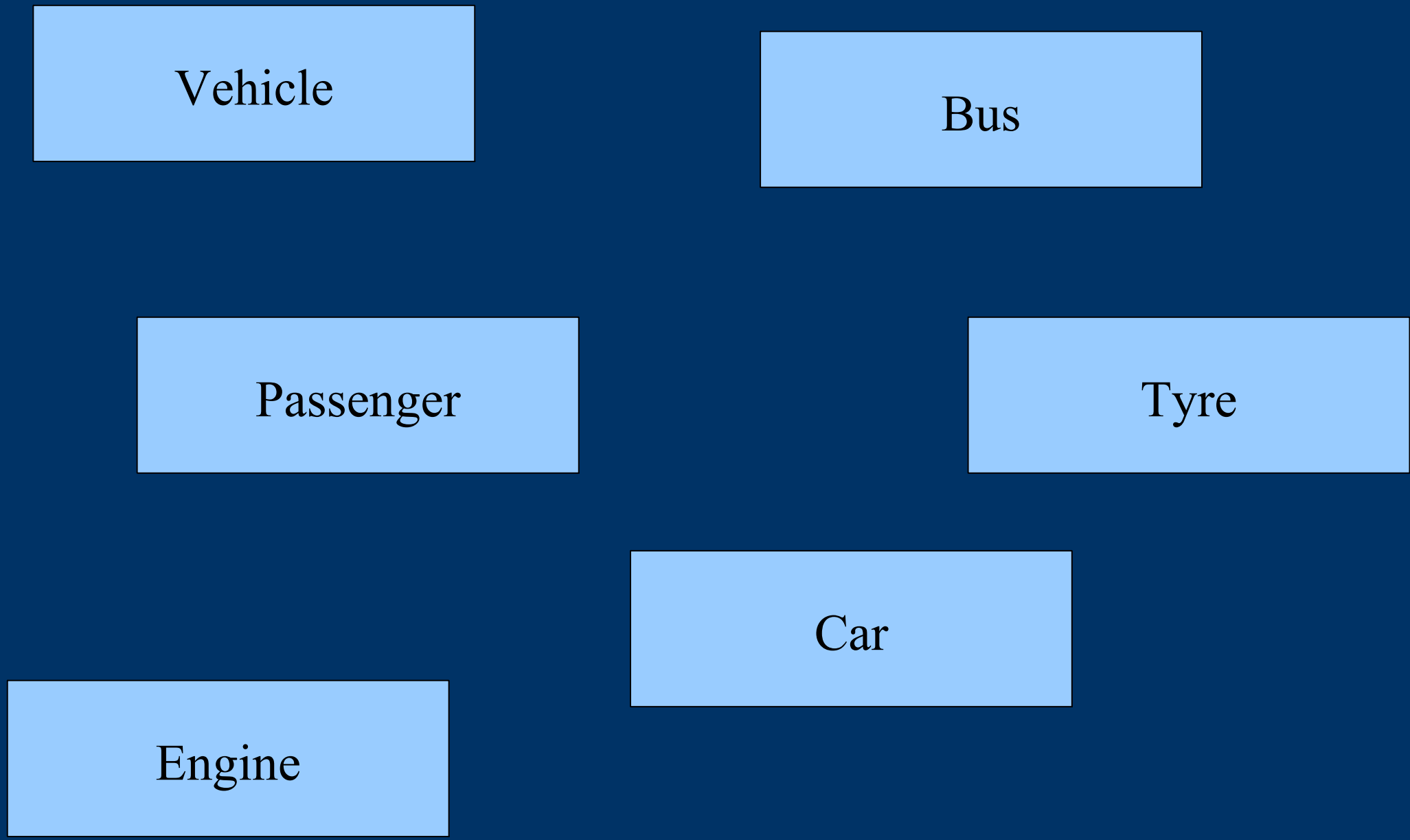
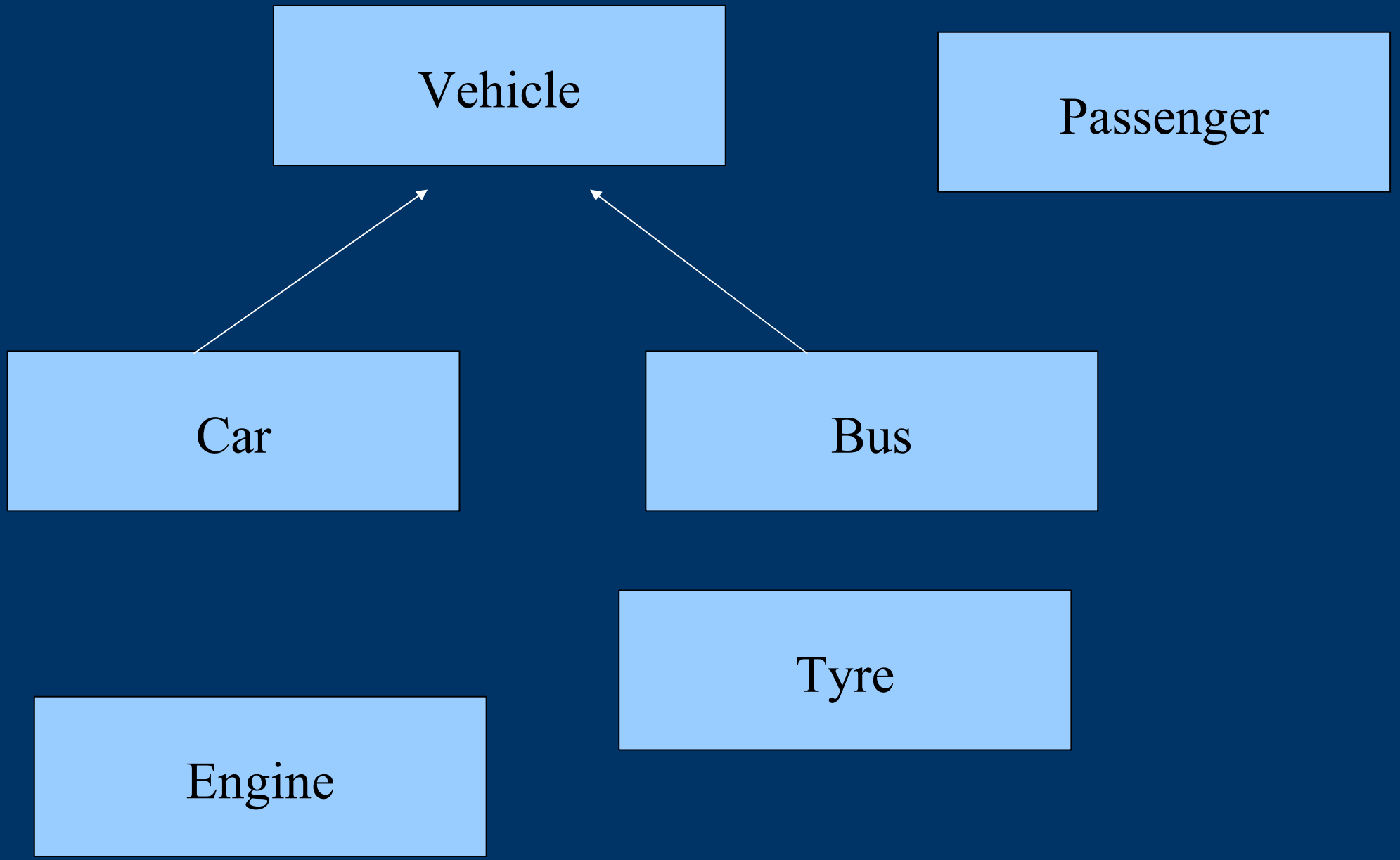
Lecture-4

Association & Aggregation


Vehicle
Bus
Passenger
Tyre
Car
Engine


Vehicle
Passenger
Car
Bus
Tyre
Engine

Association

- So far we have seen objects being sent messages within a 'main' function.
- However this does not address how objects can communicate with each other.
- In order to do this we need to have links between objects which allow them to communicate

Association

- At this level of class design this is know as an association and these come in three types
  - A one to one association where one object of a class has a link to one other object of a class
  - A one to many association, where one object of a class has links with many objects of a particular class
  - A many to many association, where many objects of one class have links with many objects of a particular class.
- Associations more frequently occur between objects of different classes, but also occur between different objects of the same class

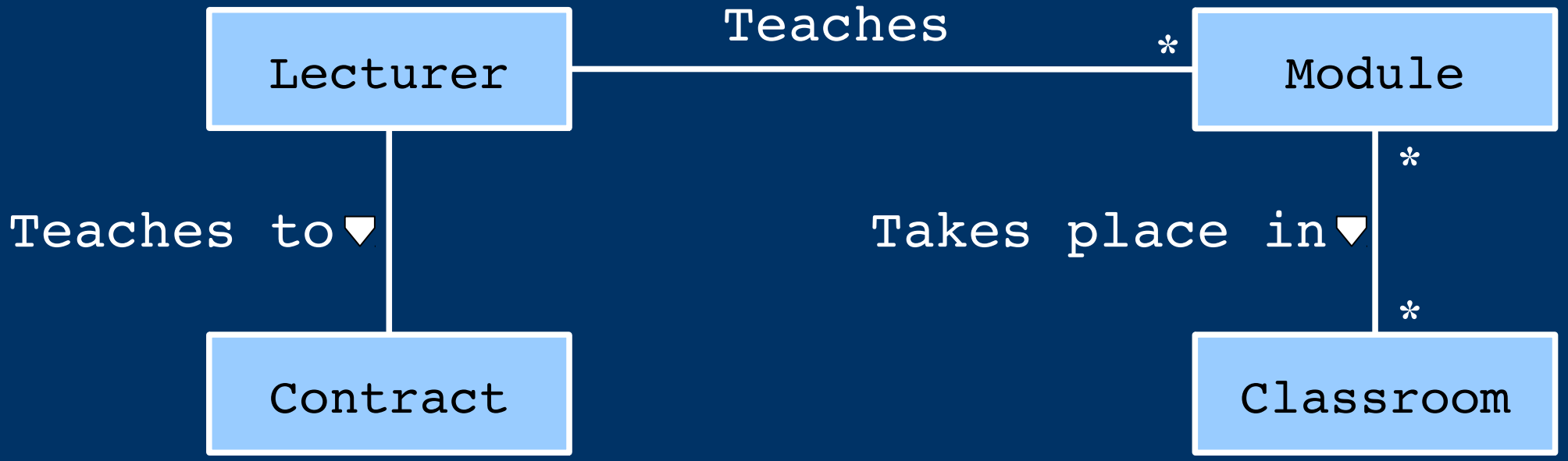
How to draw Associations (UML Notation)

Direction of message passing

- Associations are generally assumed to be bi-directional. i.e. a message can pass in both directions between objects.
- However in implementation this doesn't have to be the case as shown in the example bellow

Association in applications

- The previous example doesn't bear much relevance to a real software application
- The following example shows a more realistic diagram



The Association in a timetable example

Aggregation v. Inheritance

- A classification hierarchy shows how classes inherit from each other and shows the position in the hierarchy as 'a kind of' relationship.
- i.e. An Estate car is 'a kind of' car and a car is 'a kind of' vehicle.
- Associations also form hierarchies but they are very different from inheritance. These are described by the following terms
  - Aggregation
  - Composition
  - Part-Whole
  - A Part Of (APO)
  - Has a
  - Containment

Aggregation v. Inheritance (2)

- In this type of hierarchy, classes do not inherit from other classes but are composed of other classes
- This means that an object of one class may have it's representation defined by other objects rather than by attributes.
- The enclosing class does not inherit any attributes or methods from these other included classes.
- This means that this is a relationship (association) between objects.
- An object of the enclosing class is composed wholly or partly of objects of other classes
- **Any object that has this characteristic is know as an aggregation**

Aggregation v. Containers

- The commonly used term for this type of relationship is 'containment'
- However this is semantically different from the idea of a container
  - In 'containment', a composition hierarchy defines how an object is composed of other objects in a fixed relationship. The aggregate object cannot exist without it's components, which will probably be of a fixed and stable number, or at least will vary within a fixed set of possibilities.
  - A 'container' is an object (of a container class) which is able to contain other objects. The existence of the container is independent of whether it actually contains any objects at a particular time, and contained objects will probably be a dynamic and possibly heterogeneous collections (i.e. the objects contained may be of many different classes).

A Containment Example

- For Example A Car
  - will have an engine compartment with an integral component :- the engine
  - This is a containment relationship as the engine is an essential part of a car
- Another part of a car is the boot. What is in the boot does not effect the integrity of the car (i.e. what the car is)
  - The boot can contain many different types of objects (tools, shopping etc) but this does not affect the car object.
- Therefore the boot is a container existing independently of it's contents.

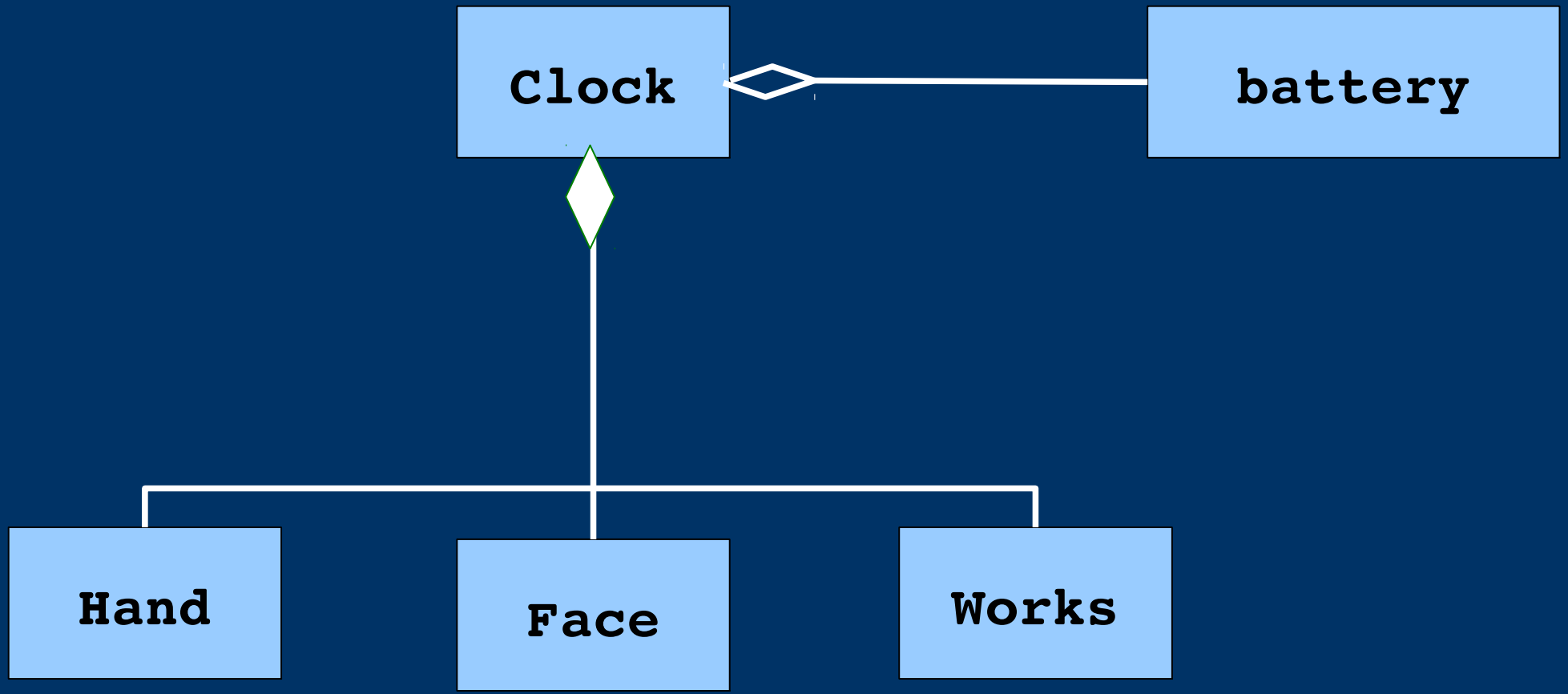
Composition: 'parts explosion'

- A common analogy for composition is the exploded parts diagram
- For example a clock can be thought of of being composed of the following parts
  - Case, Works, Face, Minute Hand, Hour Hand
- These objects may exist in many layers for example the works is an object made up of many other objects (gears, springs etc)

Aggregation or composition?

- An object which comprise parts of a larger object may or may not be visible from outside the object.
- Composition implies that the internal objects are not seen from the outside,
- Whereas aggregation shows that the object may be directly accessed and is visible from outside the object.
- In UML notation this is draw with a Diamond shape and is
  - Filled in to indicate a composition
  - Outlined (left blank) for an aggregation
- This is shown in the following Diagram

UML Diagram of Clock aggregation



Properties of Aggregations

- There are certain properties associated with objects in an aggregation that make them different from normal associations.
- These may be classed as follows

Transitivity	If A is part of B and B is part of C then A is part of C
Antisymmetry	If A is part of B, then B is not part of A. (i.e. not a simple association)
Propagation	The environment of the part is the same as that of the assembly

Properties of Aggregations (2)

- Aggregation can be fixed, variable or recursive
- These may be classed as follows

Fixed The particular numbers and types of the component parts are pre-defined.

Variable The number of levels of aggregation is fixed, but the number of parts may vary

Recursive The object contains components of its own type. (like a Russian doll)

Aggregation C++ Syntax

- There are two basic ways in which associations and aggregations are implemented

1. Objects contain Objects
2. Objects contain pointers to Objects

- The first approach is used to create fixed aggregations (objects inside objects)
- The second is used to create variable aggregations to make programs more flexible

Implementing fixed aggregations

- In C++ fixed aggregations are implemented by defining classes with objects of other classes inside of them.
- For example a simplified aircraft set of components could contain the following
    - PortWing, StarbordWing
    - Engine1, Engine2
    - Fuselage
    - Tailplane
- All of which will be contained as private elements of the class Aircraft as shown in the following class.

Aircraft Class

```
class Aircraft
{
private :
    PortWing port_wing;
    StarboardWing starboard_wing;
    Engine engine1,engine2;
    Fuselage fuselage;
    Tailplane tailplane;
};
```

- Each of the separate classes within the Aircraft class will have their own methods which can be called within the Aircraft class as shown below

Example of Methods Aircraft Class

```
void Aircraft::turnToPort()
{
 port_wing.elevatorUp();
 starboard_wing.elevatorUp();
 port_wing.aileronUp();
 starboard_wing.aileronDown();
 tailplane.rudderLeft();
}
```

- Activities of some composing objects will depend on the state of others

Example of Methods Aircraft Class

```
void Aircraft::openDoors()
{
if(engine1.getSpeed()>IDLE||engine2.getSpeed()>IDLE)
   {
     //don't open doors
   }
else
    fuselage.openDoors();
}
```

- This is an example of a propagation as the state of the Aircraft propagates to the state of the door.

Constructing Aggregations with parameters

- With aggregation we sometimes have to call parametrised constructors
- When an object is created, any contained objects must be created at the same time.
- Some objects may not have parametrised constructors so this is easy
- If some objects do need parameters in the constructors some mechanism is required to pass the parameter to the associated objects.
- This is done using the colon (:) operator as shown in the following example

Car Class Comprised of wheel and engine

```
class Wheel
{
private:
    int diameter;
public:
    Wheel(int diameter_in){ diameter = diameter_in; }
    int getDiameter() { return diameter; }
};
class Engine
{
private:
        int cc;
public:
        Engine(int cc_in)  { cc = cc_in; }
        int getCC()return cc; }
};
```

Car Class

```
class Car
{
private:
        Wheel nearside_front, offside_front,
        nearside_rear, offside_rear;
        Engine engine;
        int passengers;
public:
  Car(int diameter_in, int cc_in, int passengers_in);
  void showSelf();

};
```

Car Class

```
Car::Car(int diameter_in, int cc_in, int
passengers_in) :
          nearside_front(diameter_in),
          offside_front(diameter_in),
          nearside_rear(diameter_in),
          offside_rear(diameter_in),
          engine(cc_in)
{
        passengers = passengers_in;
}
```